



ENERGY HARVESTING USING NANO-FIBERS PVDF\GRAPHENE COMPOSITE FOR MEDICAL IMPLANTED DEVICES

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Abstract

Self powering implanted devices have been the main goal for most miniature device. Harvesting bioenergy is a remarkable method that can utilize a natural energy such as heart beat by converting the mechanical energy into electric power that can charge or even power implanted devices such as pacemaker. To achieve this goal, piezoelectric materials are used. This project is demonstrated as a novel idea of using dual layers Nano-scale film of polyvinylidene fluoride (PVDF) and Graphene composite laying on each others that are embedded into self curling biocompatible silicone. The assembly converts mechanical actions of a blood artery (pulsated pressure of expansion and contraction) into corresponding voltage. Each PVDF\ Graphene layer has dimension of $W_p=8\text{mm}$, $L_p=28\text{mm}$, and $H_p=17\mu\text{m}$. Additional, the Nano film can be attached to vibrating transmitting plate for harvesting heart beat energy and Encapsulating the whole device with a biocompatible material

Theory

PVDF is one of the semicrystalline polymers with different crystalline phases (α , β and γ phases). The polar β -PVDF phase is exhibiting the piezoelectric properties. Dynamic deformation of blood artery causes obvious of curling silicon that leads to stretch and shrinking the PVDF\Graphene Nano film. Artery's expansion creates a strain on arterial wall and silicon cuff device. Strain at both layers are converted to an electric power by means of piezoelectric effect. Open-ended silicon cuff is modeled to avoid artery restriction. Total power harvested by PVDF is calculated as summation power of each layer individually as it written below, where P_t is total power, V piezo root mean square, R load is resistance of artery.

$$P_T = P_{L1} + P_{L2} \quad \text{Eq.(1)}$$

$$P_L = \frac{V^2_{PIEZO}}{4 R_{Load}} \quad \text{Eq.(2)}$$

$$R_{LOAD} = \frac{1}{2\pi f C_{Piezo}} \quad \text{Eq.(3)}$$

Fabrication of device

Two experiments were conducted, a Nano fibers of PVDF and PVDF\ Graphene composite were produced by using far field electrospinning technique. The fibers was collected randomly along with preserved parameters conditions.



Electrospinning machine



PVDF Nano fibers film

Enhancement of PVDF thickness would have a profound improvement for increasing output power. The average power is inversely proportional to the PVDF thickness with assume resistance of Mock artery is constant at 125M Ω . At PVDF thickness of 17 μm , the corresponding average power of 30nwatt is calculated Fig.2

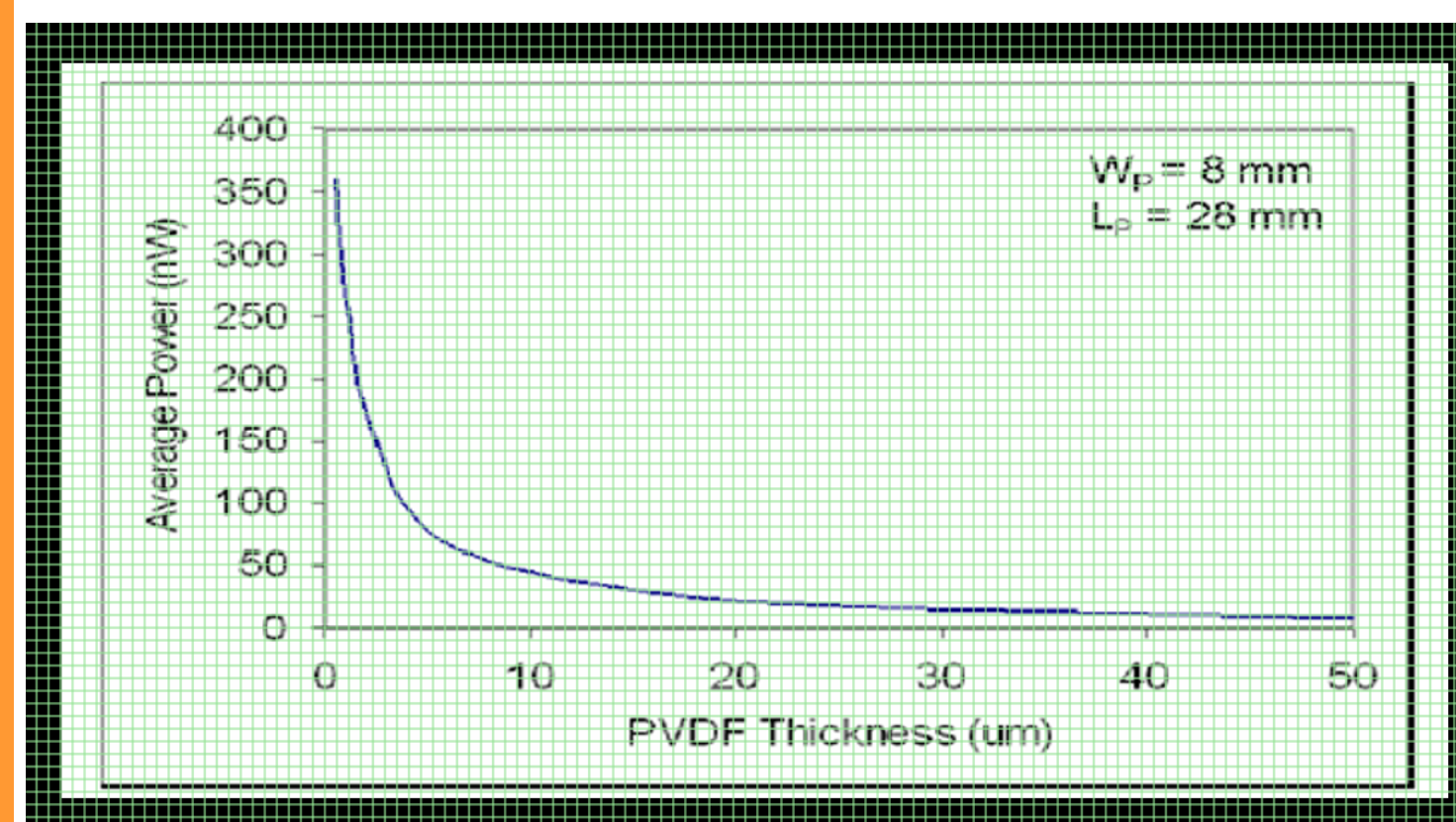


Figure 2. Relationship between average power with PVDF thickness

Application of the PVDF Nano fibers

1-PVDF\ Graphene Nano fibers can be attached to a vibrating transmitting plate (VTP), which can amplify the heart beat and then deform the film. The generated voltage is stored directly after been rectified in a super capacitor which discharge power to the pacemaker battery Fig 3

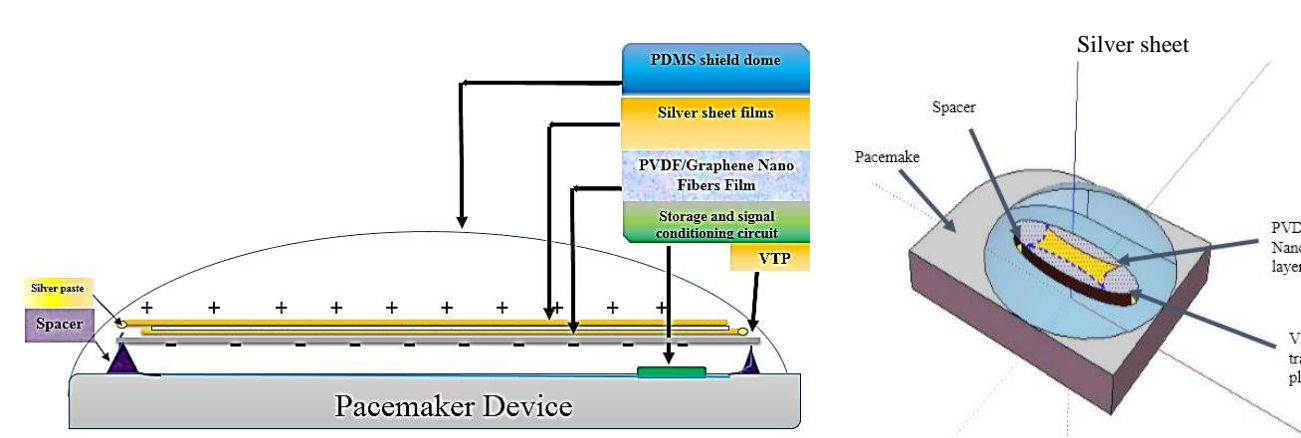


Figure 3- PVDF\Graphene Nano fibers attached to VTP
2- Self curling silicon cuff embedded with dual layer PVDF\Graphene Nano fiber may harvest the energy from expansion and contraction of an Artery and then deliver the converted power to a pacemaker.as shown in Fig 4

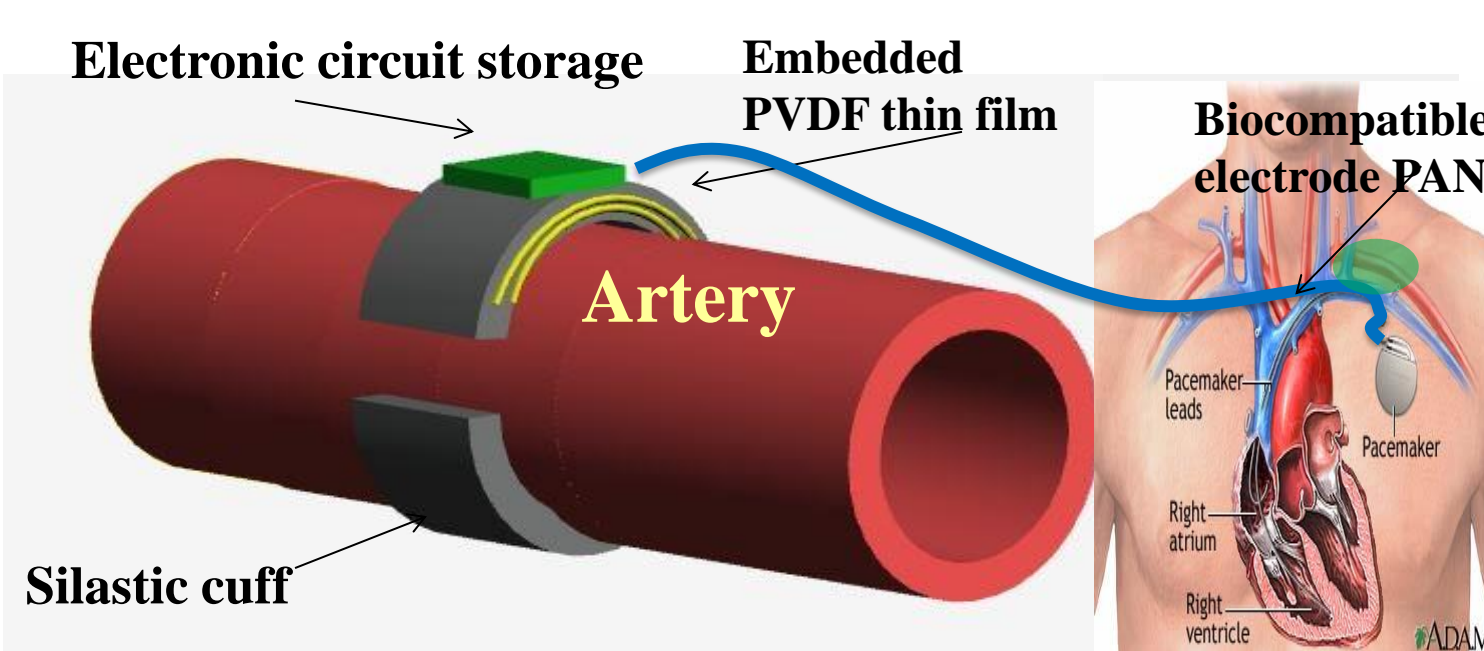


Figure 4 PVDF\Graphene Nano fibers embedded within silastic cuff

Results

The PVDF\Graphene Nano fibers composite exhibited less non polar α phase PVDF and than the absolute PVDF Nano fibers as shown by the X-ray diffraction in fig.5

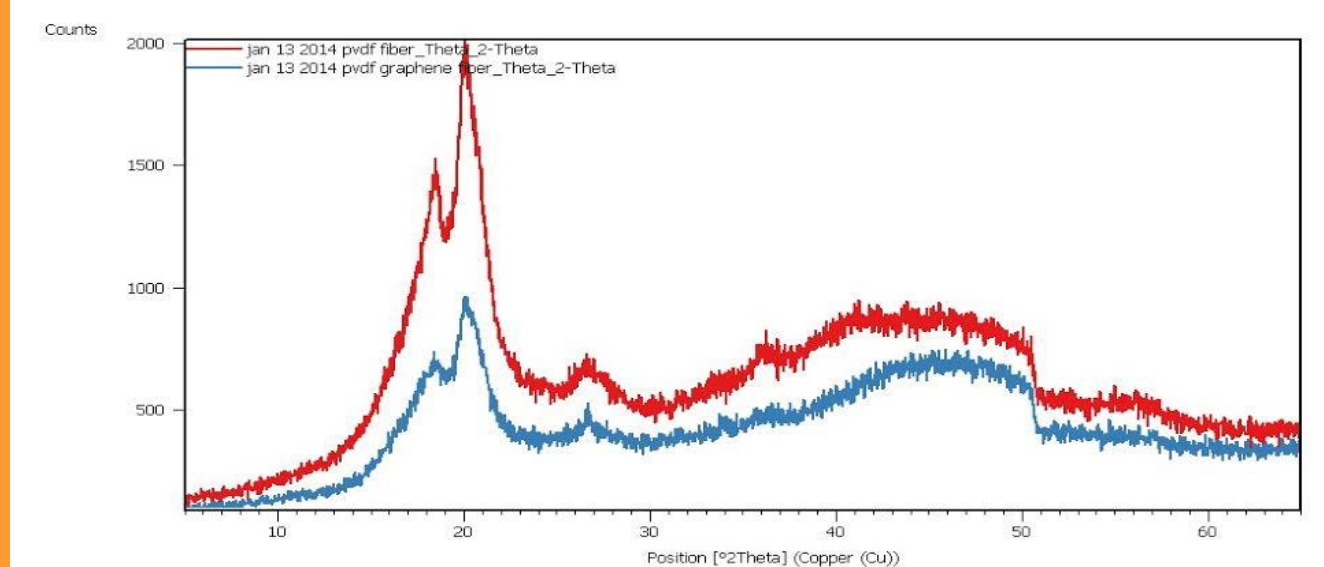


Figure 5-XRD analysis for PVDF and PVDF\ Graphene composite
Table below shows an obvious difference of harnessed power when we changed thickness of PVDF to 17 μm . Power is calculated theoretically and approximately is twice order than achieved in vitro. The produced Nano fibers film is embedded into silicon 0.30 cm^3 cuff .The device is calculated to get average peak voltage of 3.8 v

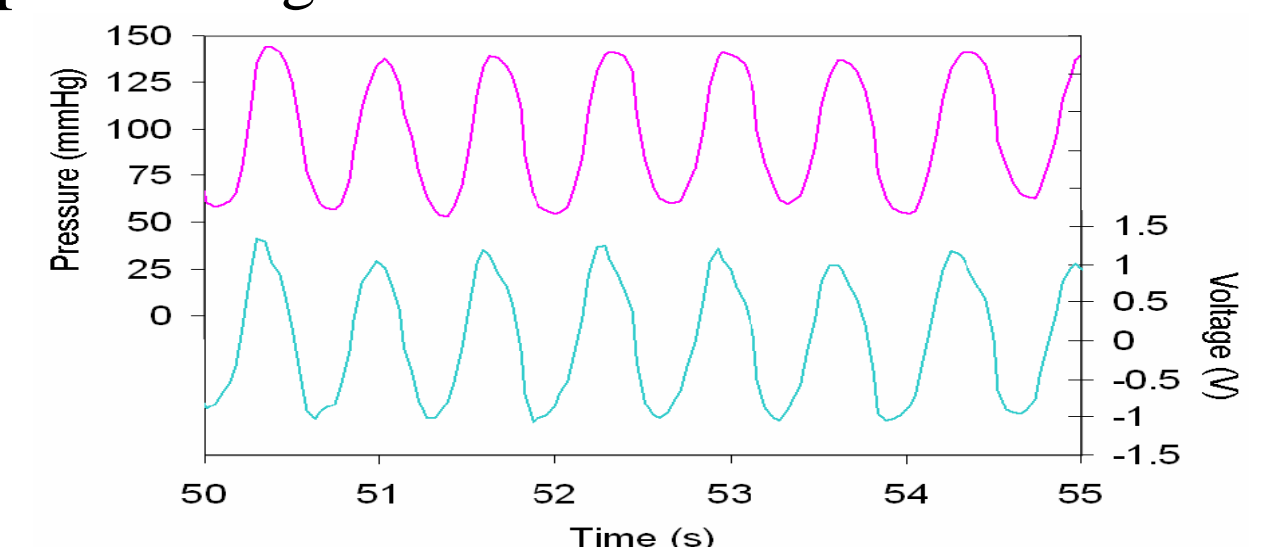


Figure 6-PVDF response with applied pulsatile pressure input

Design	V peak (v)	Thickness	Power (w)	R load (Ω)
Current	2.8	28 μm	16nw	125M
Proposed	3.8	17 μm	30nw	125M

Table 1

CONCLUSION

Electrospun of PVDF with Graphene was collected as a thin fiber using FFES during fabrication. Generally, Nano PVDF/ Graphene has tremendous applications due to capabilities of power harvesting. Nano fibers film used to harnesses mechanical blood pressure from an artery/ harvesting energy from heart beat by using vibration transmitting plate. Shielding the assembly with PDMS makes a brilliant biocompatible, sustainable device. With the Nano-scale fiber we expect least two orders of magnitude higher power harvesting that result in producing peak voltage of 3.8 and 60nw for double layers enough to charge or power a pacemaker.

References

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